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VOLUME 1

INVESTIGATIONS ON PURE MATHEMATICS, FINANCE MATHEMATICS AND OPTICS

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$$\varphi_1(x, y, z) = z$$

$$\pi_1 = \begin{pmatrix} x & y & z \\ y & z & x \end{pmatrix}$$

$$z' = x^2 + y^2 + z^2 + 2yz$$

$$\pi_1 \vee_1 \pi_1 = \vee_{17}$$



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Investigations on Pure Mathematics, Finance Mathematics and Optics

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Contents

Preface

Part I Pure Mathematics Concentration

Chapter 1	THE BEHAVIOR OF TRAJECTORY OF ξ^s QUADRATIC STOCHASTIC OPERATIONS	2
Chapter 2	THEORY OF MARKOV CHAINS IN PEDIATRIC DISEASES	8
Chapter 3	ON NONLINEAR DYNAMIC SYSTEMS ARISING IN POTTS MODEL	14
Chapter 4	THE FIRST RETURN TIME AND DIMENSION	22
Chapter 5	ON AS SOCIATIVE ALGEBRAIC STRUCTURE OF GENETIC INHERITANCE	31
Chapter 6	INTERACTING PARTICLE SYSTEM	37
Chapter 7	DYNAMICS OF GENERALIZED LOGISTIC MAPS	43
Chapter 8	GEOMETRIC BROWNIAN MOTION AND CALCULATION OF OPTION PREMIUM IN BLACK SCHOLES MODEL	50
Chapter 9	ON THE ELEMENTARY CHARACTEFIZATION OF PRIMES IN PRIMALITY TESTS: TWO SHORT STUDIES.	57
Chapter 10	ON ASSOCIATIVE ALGEBRAIC STRTJCTURE OF GENETIC INHERITANCE	64
Chapter 11	SOME APPLICATION OF ERGODIC THEORY IN NUMBER THEORY	70
Chapter 12	STUDY OF ROLES OF EXTERNAL MAGNETIC FIELD ON ISING AND POTTS MODEL	76
Chapter 13	INVESTIGATION OF STABILITY OF FIXED POINTS OF NONLINEAR DISCRETE DYNAMICAL SYSTEMS	82
Chapter 14	MARKOV CHAINS AND ITS APPLICATION: THE INVENTORY MODEL	90
Chapter 15	PHASE TRANSITION FOR ISING MODEL WITH TWO COMPETING INTERACTION ON CAYLEY TREE OF ORDER 4	96
Chapter 16	LIMIT BEHAVIOR OF DYNAMIC SYSTEMS CORRESPONDING TO LATTICE MODELS WITH COMPETING PROLONGED AND ONE-LEVEL BINARY INTERACTIONS	101
Chapter 17	ASSOCIATIVE ALGEBRA IN GENETIC INHERITANCE	109
Chapter 18	ON ξ^a - QUADRATIC STOCHASTIC OPERATORS AND THEIR CLASSIFICATIONS	115

Part II Finance Mathematics Concentration

Chapter 19	ANALYZING THE PERFORMANCE OF INVESTMENT STRATEGY OF EPF	123
Chapter 20	PREDICTION OF STOCK PRICE USING NEURAL NETWORK	130
Chapter 21	COMPARISON BETWEEN CONVENTIONAL AND ISLAMIC BOND IN MALAYSIA	136
Chapter 22	STOCK PERFORMANCE ANALYSIS BETWEEN MALAYSIAN AIRLINES SYSTEM BERHAD AND AIRASIA BERHAD	144
Chapter 23	ISLAMIC PAWNBROKING (AR-RAHNU) AS A MICRO CREDIT INSTRUMENT IN MALAYSIA	151
Chapter 24	ANALYSIS OF CRUDE PALM OIL FUTURES PRICES TRADED ON BURSA MALAYSIA	160
Chapter 25	AN EMPIRICAL STUDY ON THE EFFICIENCY OF THE TRIM AND FILL METHOD IN CORRECTING PUBLICATION BIAS IN META ANALYSIS	166
Chapter 26	PERFORMANCE ANALYSIS OF INSURANCE AND TAKAFUL INDUSTRIES IN MALAYSIA	171
Chapter 27	ANALYSIS OF DATA USING MULTILEVEL MODELLING WITH MLwiN	179
Chapter 28	FINANCIAL PERFORMANCE OF ISLAMIC BANKING AND CONVENTIONAL BANKING IN MALAYSIA	186
Chapter 29	A STUDY ON THE EFFECT OF PUBLICATION BIAS IN META ANALYSIS	194
Chapter 30	RATIO ANALYSIS: BANK ISLAM MALAYSIA BERHAD (BIMB) & MALAYAN BANKING BERHAD (MAYBANK)	201
Chapter 31	AN ANALYSIS OF MALAYSIAN UNIT TRUST FUNDS: ISLAMIC VS CONVENTIONAL	207

Part III Optics Concentration

Chapter 32	QUANTUM TRAJECTORY METHOD USING MPI PARALLEL COMPUTING	214
Chapter 33	LINEAR WAVE PROPAGATION IN SINGLE MODE OPTICAL FIBRE	220
Chapter 34	THE OPTICAL RAY TRACING TECHNIQUE IN LENS SYSTEM WITHIN AND BEYOND PARAXIAL APPROXIMATION	226
Chapter 35	WAVE PROPAGATION IN NONLINEAR AND HOMOGENEOUS MEDIA: KERR MEDIA	234
Chapter 36	MATRIX METHODS OF OPTICAL RESONATORS	240

QUANTUM TRAJECTORY METHOD USING MPI PARALLEL COMPUTING

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Abstract. *Quantum Trajectory Method (QTM) is a numerical Monte-Carlo analysis used to solve the master equation describing the interaction between a quantum system and a Markovian reservoir. Basically, the master equation is a differential equation of the density matrix (operator) dynamics, which describes the dynamics of an “ensemble” rather than the “individual behavior” of the element of the ensemble. The implementation of QTM on the other hand, produces a single quantum trajectory which represents the evolution of the system wave function conditioned to a series of quantum jumps at random times. The evolution of the system density matrix is obtained by taking the average over many quantum trajectories. With respect to that, it has computing time disadvantage since one has to generate many trajectories to get better approximation. Fortunately, using the MPI library; the trajectories can be generated in parallel thus can significantly improve the computation time.*

1 Introduction

This project is actually studying the implementation of MPI library to parallelize the computation in Quantum Trajectory Method. The specific task chosen is this study is to reproduce the results of quantum trajectory simulation of a cavity QED laser (or microlaser) reported by Ting Kai Ling et. all. (1998). Nevertheless, in this project; the calculation is executed parallel using MPI library on a Beowulf cluster computer known as ROCKS cluster (Rocks: About, 2008). It is of interest also to study the performance of this system as an alternative parallel computing to the very expensive supercomputer such as Cray, SGI etc.

2 Quantum Trajectory Method and MPI Library

Below is a summary of the central idea of the Quantum Trajectory simulation:

$$\otimes p(t) = \Delta t \frac{\langle \bar{\Psi}_c(t) | \hat{C}^\dagger \hat{C} | \bar{\Psi}_c(t) \rangle}{\langle \bar{\Psi}_c(t) | \bar{\Psi}_c(t) \rangle} \geq R \in [0,1)$$

then

$$|\bar{\Psi}_c\rangle \leftarrow C|\bar{\Psi}_c\rangle$$

Else

$$i\hbar \frac{d}{dt} |\bar{\Psi}_c\rangle = \tilde{H} |\bar{\Psi}_c\rangle$$

End if

$$t \leftarrow t + \Delta t$$

go to \otimes

End

Taking the average over many such quantum trajectory reproduces the result of the corresponding master equation. For example, if an ensemble of such trajectories is generated starting from the same initial state, the ensemble average of $\rho_c(t)$ is the density operator $\rho(t)$. Note however that when $\rho(t)$ comes to a steady state, $\rho_c(t)$ will not, each trajectory keeps up